

**Strongly Anisotropic Magnesio-wüstite in Earth's Lower Mantle**

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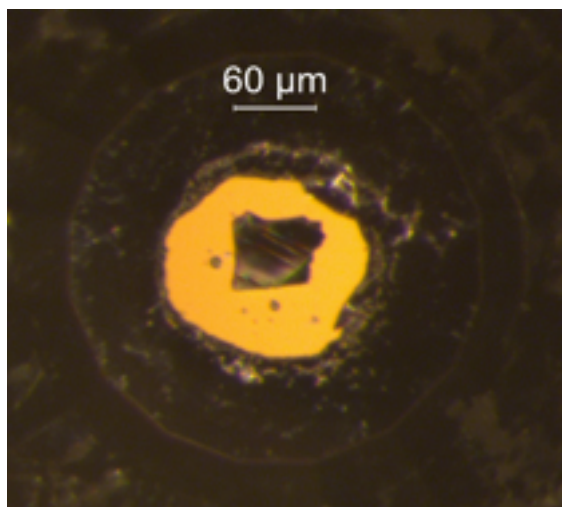
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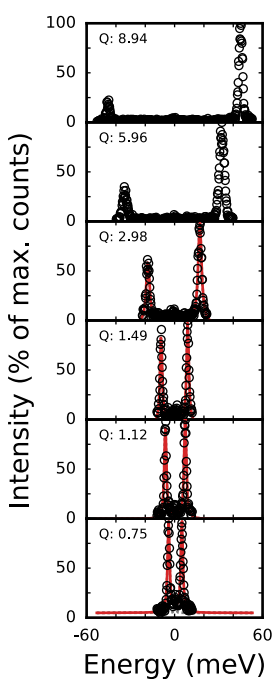
**Introduction**

The supporting information enclosed in this document includes (1) an image of the sample chamber at high pressure, (2) the HERIX spectra collected at every pressure, and (3) tables with tabulated elasticity and velocity values determined from HERIX and diffraction data.

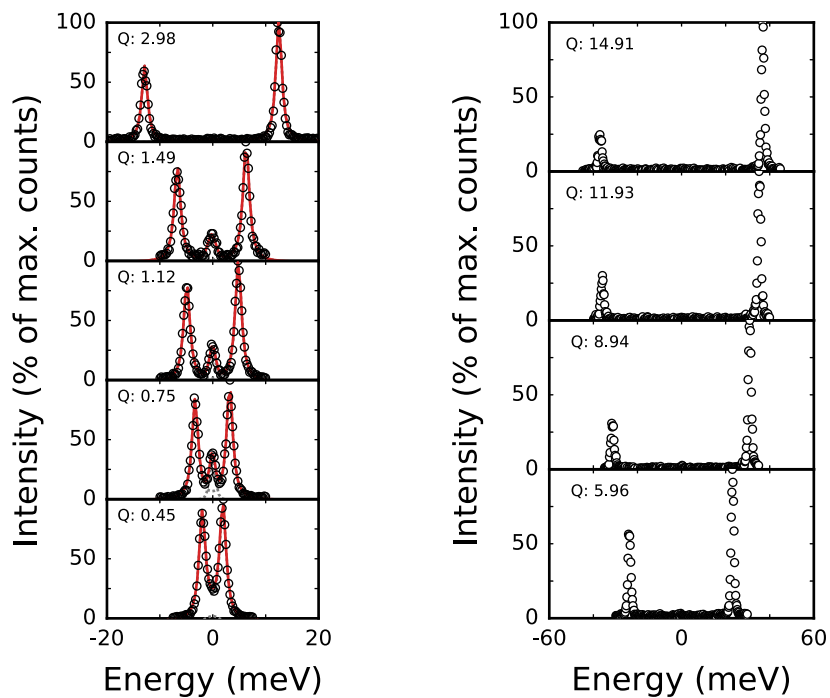


**Figure S1.** The sample chamber of the diamond anvil cell used for HERIX measurements at 30.9 GPa. The sample assembly consists of a magnesiowüstite single crystal and two ruby spheres that are surrounded by a helium pressure medium.

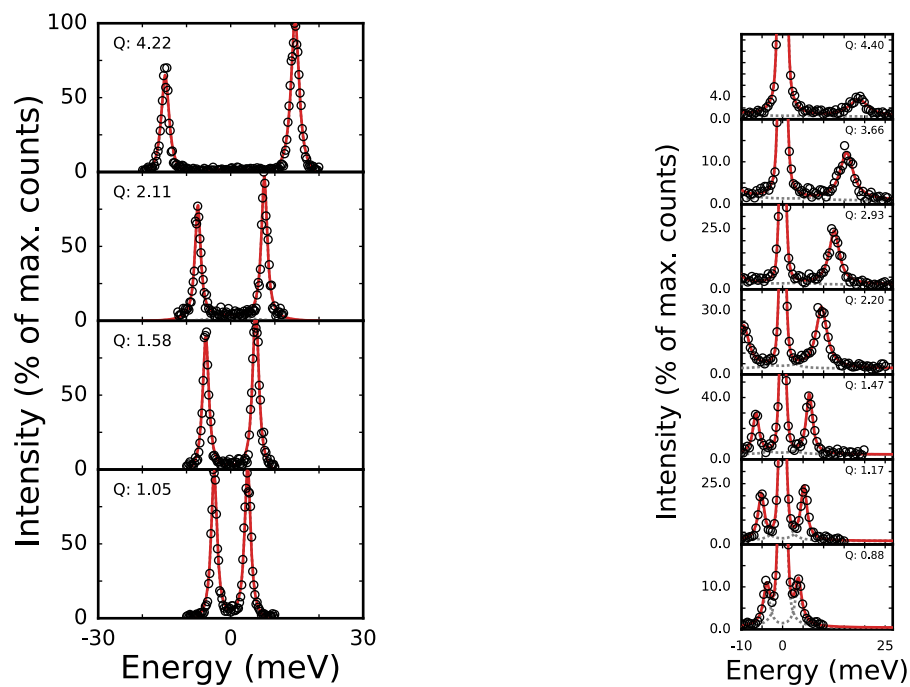
**Figures S2a-x.** MgO HERIX spectra at ambient conditions (**a-c**), and Mw HERIX spectra at ambient conditions (**d-f**) and high pressure (**g-x**). The black circles show the raw HERIX data, the red line represents the complete fit to a spectrum, and the gray dotted line illustrates individual components of the fit. Spectra are labeled with the measurement direction ([100] or [110]), the mode type (longitudinal or transverse acoustic (LA or TA)), and the sample pressure.



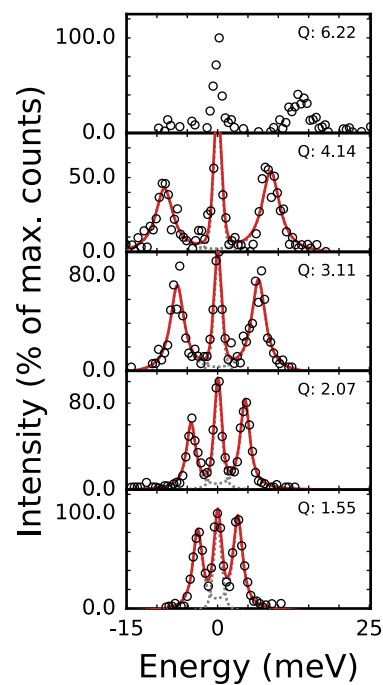
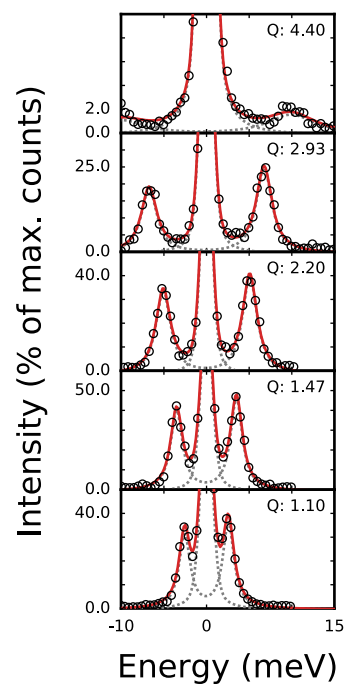
**Figure S2a.** MgO [100] LA mode at room pressure.



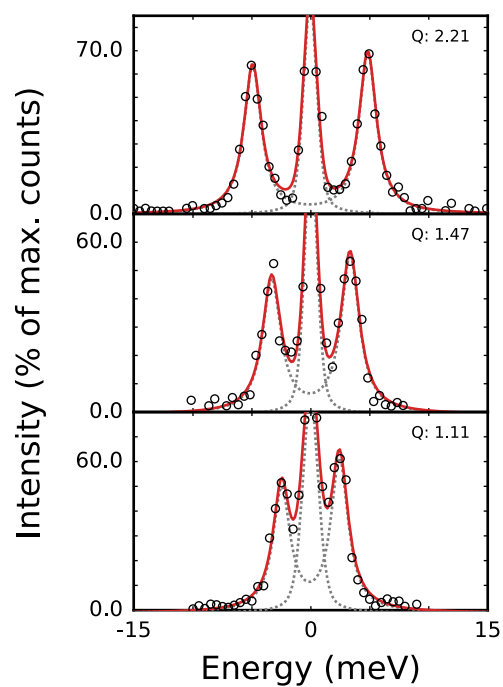
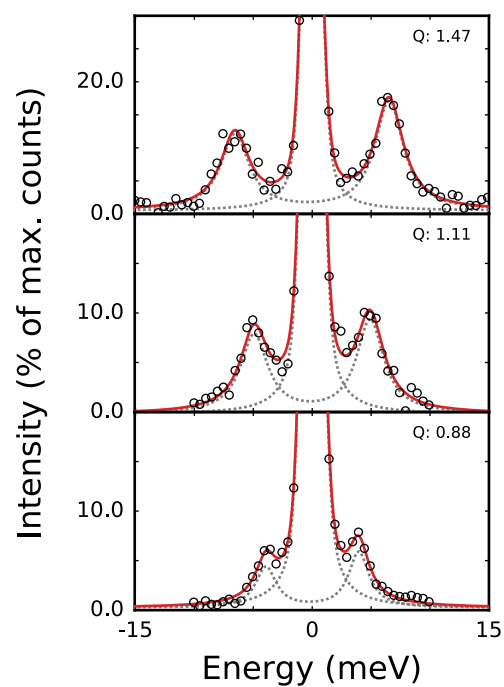
**Figure S2b.** MgO [100] TA mode at room pressure.



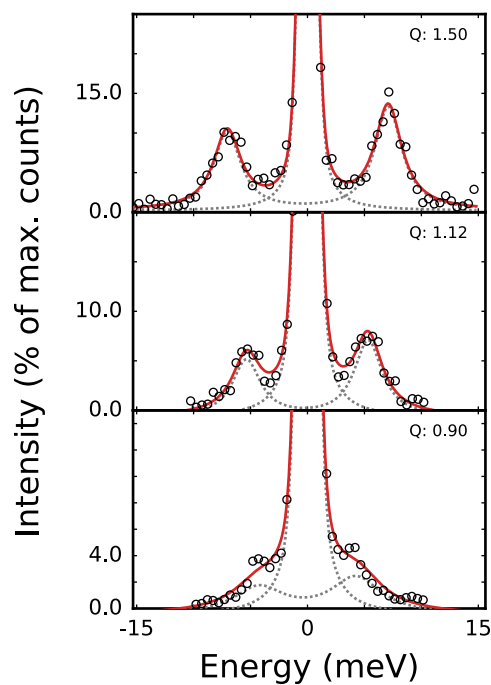
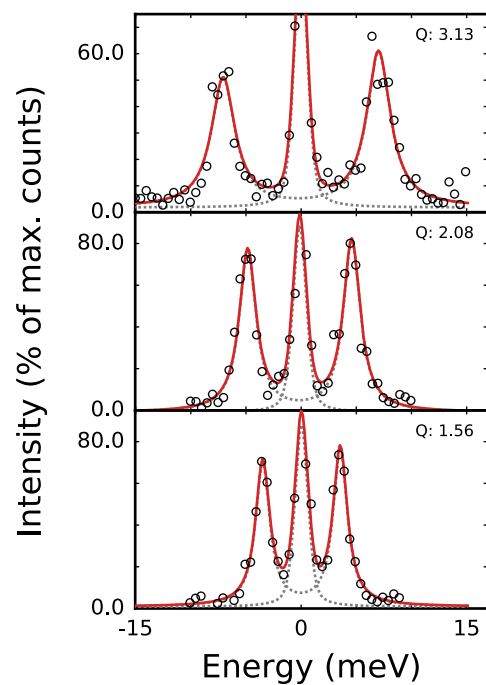
*Left: Figure S2c.* MgO [110] TA mode at room pressure. *Right: Figure S2d.* Mw [100] LA mode at room pressure.



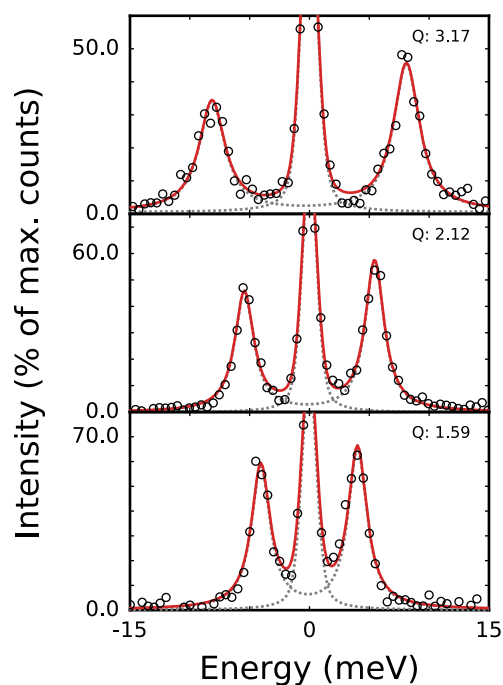
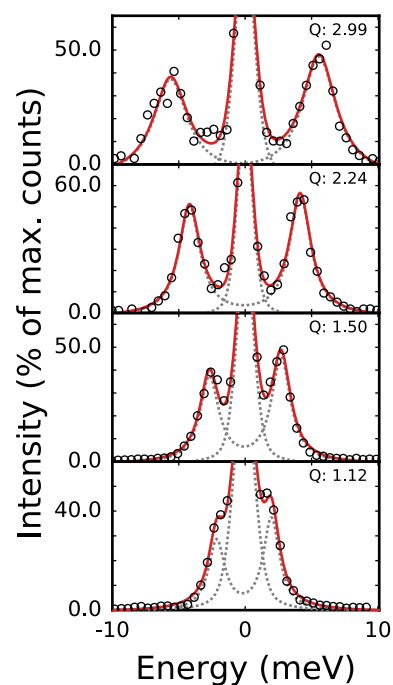
*Left: Figure S2e.* Mw [100] TA mode at room pressure. *Right: Figure S2f.* Mw [110] TA mode at room pressure.



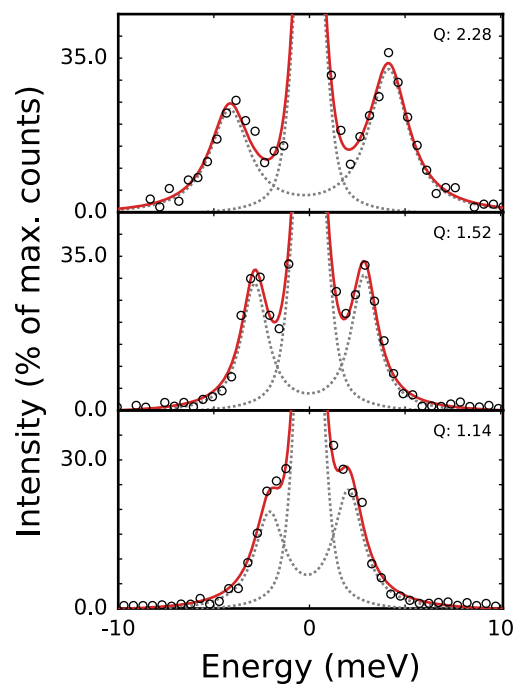
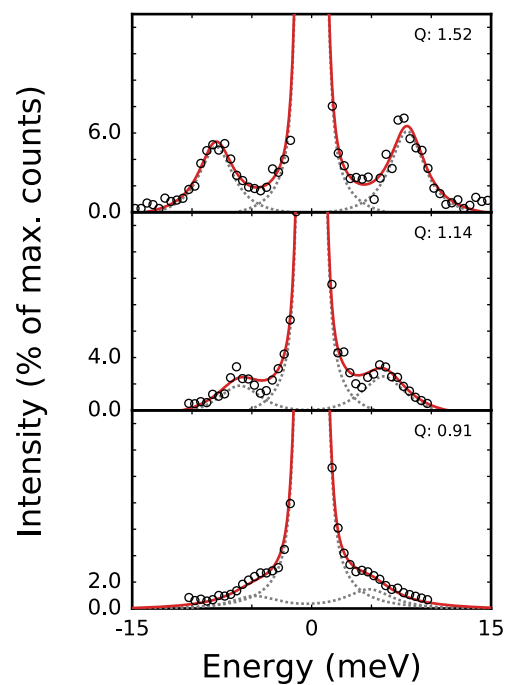
*Left: Figure S2g.* Mw [100] LA mode 2.8 GPa. *Right: Figure S2h.* Mw [100] TA mode 2.8 GPa.



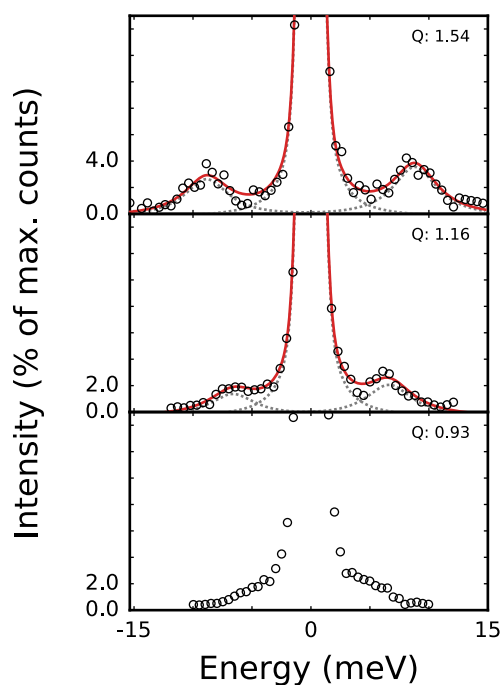
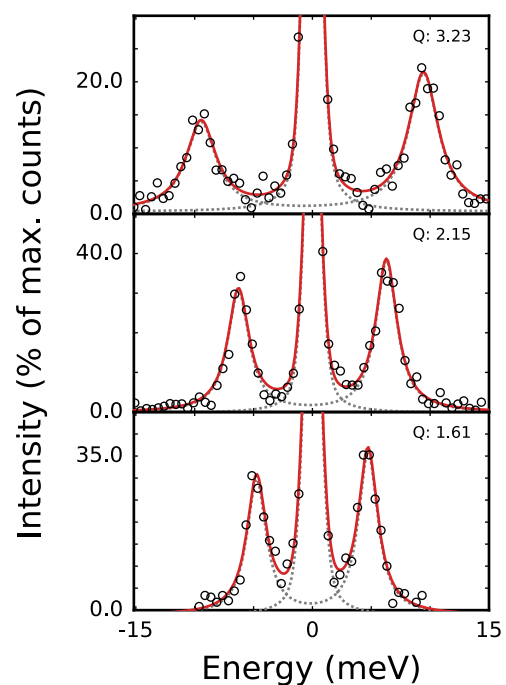
*Left: Figure S2i.* Mw [110] TA mode 2.8 GPa. *Right: Figure S2j.* Mw [100] LA mode 10.5 GPa.



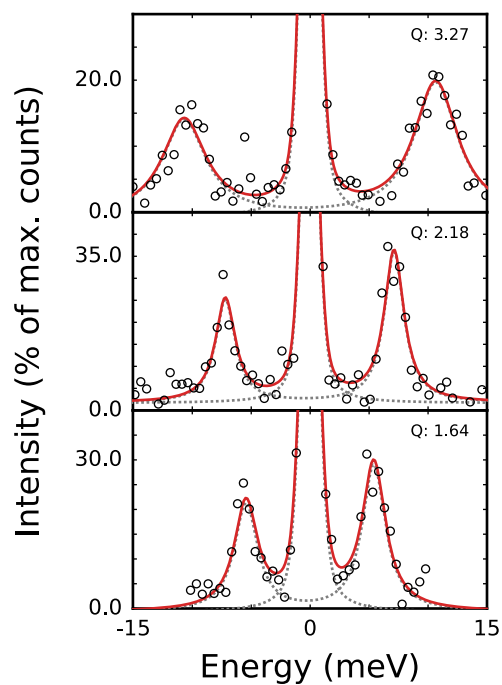
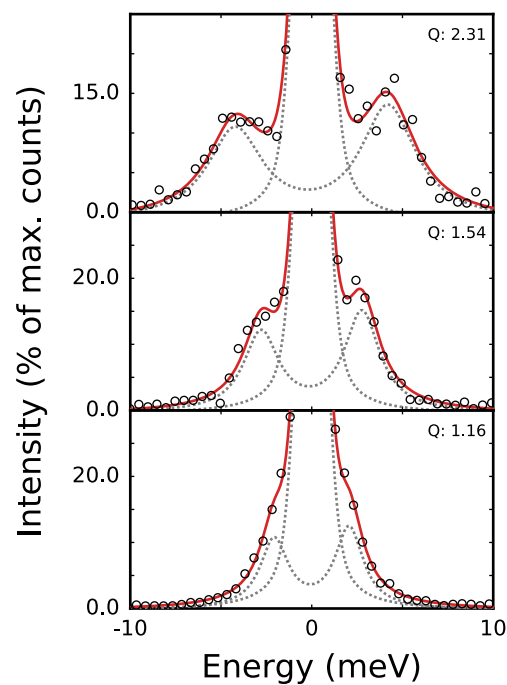
*Left: Figure S2k.* Mw [100] TA mode 10.5 GPa. *Right: Figure S2l.* Mw [110] TA mode 10.5 GPa.



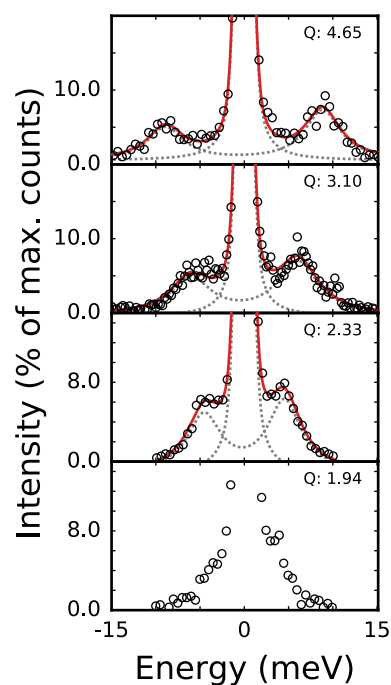
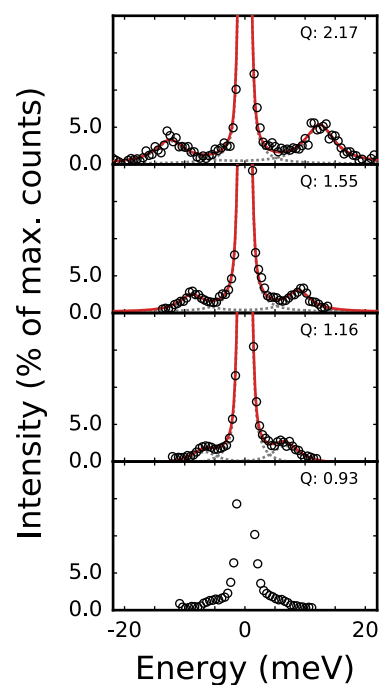
*Left: Figure S2m.* Mw [100] LA mode 21.1 GPa. *Right: Figure S2n.* Mw [100] TA mode 21.1 GPa.



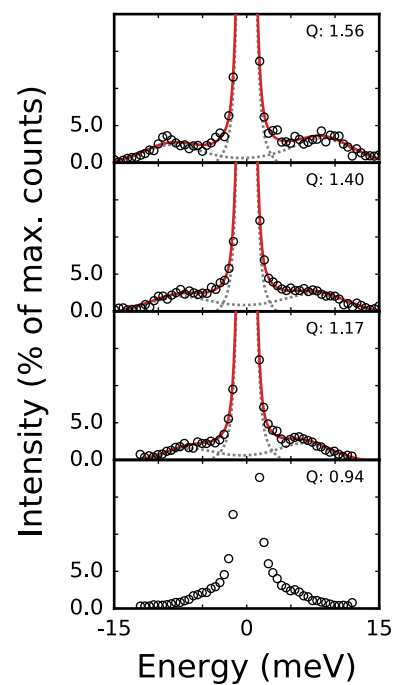
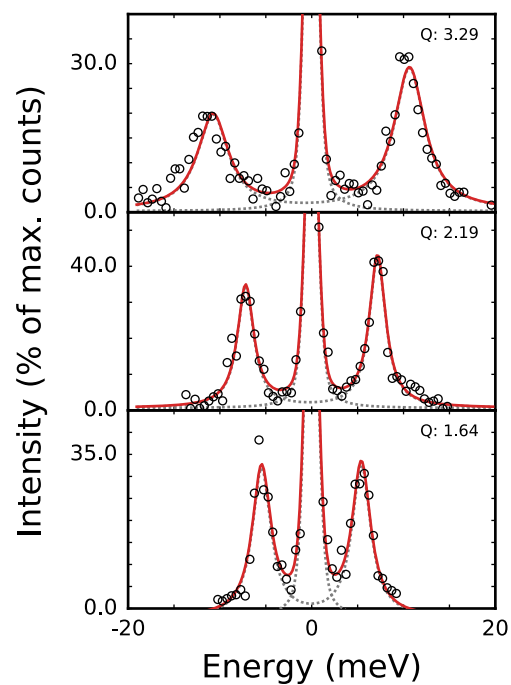
*Left: Figure S2o.* Mw [110] TA mode 21.1 GPa. *Right: Figure S2p.* Mw [100] LA mode 30.9 GPa.



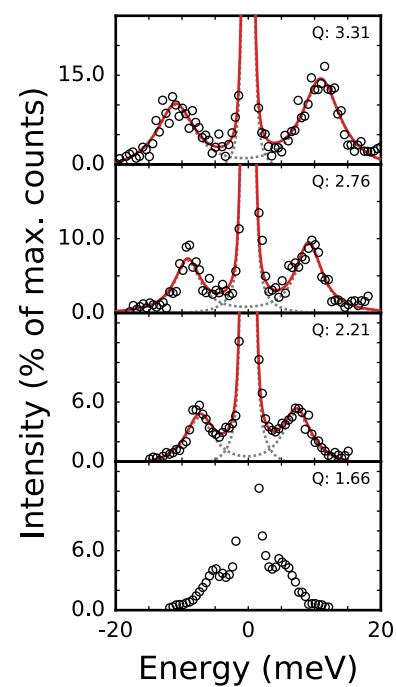
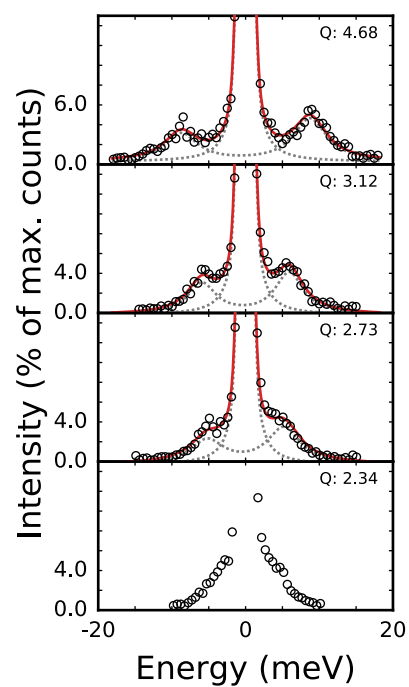
*Left: Figure S2q.* Mw [100] TA mode 30.9 GPa. *Right: Figure S2r.* Mw [110] TA mode 30.9 GPa.



*Left: Figure S2s.* Mw [100] LA mode 35.4 GPa. *Right: Figure S2t.* Mw [100] TA mode 35.4 GPa.



*Left: Figure S2u.* Mw [110] TA mode 35.4 GPa. *Right: Figure S2v.* Mw [100] LA mode 41.2 GPa.



*Left: Figure S2w.* Mw [100] TA mode 41.2 GPa. *Right: Figure S2x.* Mw [110] TA mode 41.2 GPa.



Pressure (GPa)	[100] $V_p$ Parameter (m/s)	[100] $V_p Q_{\max}$ Parameter (nm <sup>-1</sup> )	[100] $V_s$ Parameter (m/s)	[100] $V_s Q_{\max}$ Parameter (nm <sup>-1</sup> )	[110] $V_s$ Parameter (m/s)	[110] $V_s Q_{\max}$ Parameter (nm <sup>-1</sup> )
0	9193(23)	14.91(10)	6593(22)	14.91(10)	5407(17)	21.08(11)

**Table S1a.** MgO phonon dispersion fitting parameters

Pressure (GPa)	[100] $V_p$ Parameter (m/s)	[100] $V_p Q_{\max}$ Parameter (nm <sup>-1</sup> )	[100] $V_s$ Parameter (m/s)	[100] $V_s Q_{\max}$ Parameter (nm <sup>-1</sup> )	[110] $V_s$ Parameter (m/s)	[110] $V_s Q_{\max}$ Parameter (nm <sup>-1</sup> )
0	6641(23)	14.64(10)	3562(22)	14.65(10)	3272(23)	20.72(11)
2.8(6)	6772(64)	14.74(11)	3402(33)	14.74(10)	3446(29)	20.84(10)
10.5(7)	7219(72)	14.96(11)	2849(25)	14.96(10)	3918(24)	21.16(10)
21.1(9)	8018(123)	15.22(11)	2807(35)	15.22(11)	4475(30)	21.52(10)
30.9(1.1)	8732(170)	15.42(10)	2772(47)	15.42(10)	5009(43)	21.81(11)
35.4(1.1)	8776(124)	15.50(10)	3004(38)	15.50(11)	4996(32)	21.92(10)
41.2(1.3)	8387(222)	15.61(10)	2937(59)	15.61(10)	5075(47)	22.07(10)

**Table S1b.** Magnesiowüstite phonon dispersion fitting parameters

Study	Technique	Lattice Parameter (Å)	Density (g/cc)	[100] V <sub>p</sub> (km/s)	[100] V <sub>s</sub> (km/s)	[110] V <sub>s</sub> (km/s)	C <sub>11</sub> (GPa)	C <sub>12</sub> (GPa)	C <sub>44</sub> (GPa)	K <sub>s</sub> (GPa)	G <sub>H</sub> (GPa)	Isotropic V <sub>p</sub> (km/s)	Isotropic V <sub>s</sub> (km/s)
This Study	HERIX	4.215	3.5755	9.20(3)	6.59(3)	5.408(16)	302(3)	93(3)	155.5(1.4)	163(3)	132.6(1.6)	9.75(5)	6.09(4)
Sinogeikin et al. (2000)	Brillouin	4.218	3.567	9.139*	6.571*	5.323*	297.9(1.5)	95.8(1.0)	154(2)	163.2(1.0)	130.3(1.0)	9.72(4)	6.04(3)
Jacobsen et al. (2002)	Ultrasonic	4.212	3.584	9.119(32)	6.620(43)	5.361*	298(2)	92(5)	157(2)	160(3)	133(2)	9.70(7)	6.09(5)

\*Calculated from elastic constants and density.

**Table S2a.** MgO densities, velocities, and elastic constants at ambient conditions

Pressure* (GPa)	Lattice Param. (Å)	Density (g/cc)	[100] V <sub>p</sub> (km/s)	[100] V <sub>s</sub> (km/s)	[110] V <sub>s</sub> (km/s)	C <sub>11</sub> (GPa)	C <sub>12</sub> (GPa)	C <sub>44</sub> (GPa)	K <sub>s</sub> (GPa)	G <sub>H</sub> (GPa)	Isotropic V <sub>p</sub> (km/s)	Isotropic V <sub>s</sub> (km/s)
0	4.2881	5.3716	6.64(3)	3.56(3)	3.27(3)	237.0(1.7)	122(3)	68.2(9)	160.3(1.7)	63.7(1.1)	6.76(4)	3.44(3)
2.8(6)	4.263	5.4688	6.77(7)	3.40(4)	3.45(3)	251(5)	121(6)	63.3(1.3)	164(4)	64(3)	6.76(7)	3.42(7)
10.5(7)	4.2	5.7193	7.22(8)	2.85(3)	3.92(3)	298(6)	123(7)	46.4(8)	181(5)	60(3)	6.76(8)	3.24(6)
21.1(9)	4.129	6.0202	8.02(13)	2.81(4)	4.48(3)	387(12)	146(11)	47.4(1.2)	226(9)	70(4)	7.28(11)	3.40(8)
30.9(1.1)	4.075	6.2633	8.73(17)	2.77(5)	5.01(5)	478(19)	163(20)	48.1(1.7)	268(15)	79(5)	7.72(16)	3.56(11)
35.4(1.1)	4.053	6.366	8.78(13)	3.01(4)	5.00(4)	491(14)	173(15)	57.5(1.5)	279(11)	88(4)	7.88(12)	3.71(9)
41.2(1.3)	4.026	6.4952	8.4(3)	2.94(6)	5.08(5)	457(24)	122(25)	56(3)	234(19)	88(7)	7.4(3)	3.69(14)

\*Pressure determined from using measured lattice parameter with Mw in helium 3<sup>rd</sup>-order Birch-Murnaghan equation of state (34), with parameters K<sub>0T</sub> = 148(3) GPa, K'<sub>0T</sub> = 4.09(12), and V<sub>0</sub> = 78.87(6) Å<sup>3</sup>.

**Table S2b.** Magnesioiwüstite densities, velocities, and elastic constants as a function of pressure

Pressure (GPa)	Min. $V_p$ (km/s)	Max. $V_p$ (km/s)	Min/Max $V_p$ Direction	Min. $V_s$ (km/s)	Max. $V_s$ (km/s)	Min/Max $V_s$ Direction	$V_p$ Anisotropy (%)	$V_s$ Anisotropy (%)
0	9.180	10.161	[100]/[111]	5.400	6.587	[110]/[100]	10.1(5)	19.8(6)

**Table S3a.** MgO maximum and minimum velocity magnitudes and directions, and corresponding percent anisotropy

Pressure (GPa)	Min. $V_p$ (km/s)	Max. $V_p$ (km/s)	Min/Max $V_p$ Direction	Min. $V_s$ (km/s)	Max. $V_s$ (km/s)	Min/Max $V_s$ Direction	$V_p$ Anisotropy (%)	$V_s$ Anisotropy (%)
0	6.642	6.839	[100]/[111]	3.272	3.563	[110]/[100]	2.9(7)	8.5(1.3)
2.8	6.744	6.775	[111]/[100]	3.402	3.448	[100]/[110]	0.5(1.5)	1.3(1.5)
10.5	6.521	7.218	[111]/[100]	2.848	3.911	[100]/[110]	10.2(1.7)	31.4(1.3)
21.1	6.935	8.018	[111]/[100]	2.806	4.474	[100]/[110]	14.5(2.5)	45.8(1.5)
30.9	7.282	8.736	[111]/[100]	2.771	5.015	[100]/[110]	18.2(3.1)	57.6(1.9)
35.4	7.475	8.782	[111]/[100]	3.005	4.998	[100]/[110]	16.1(2.3)	49.8(1.5)
41.2	6.89	8.388	[111]/[100]	2.936	5.078	[100]/[110]	19.6(5.6)	53.5(2.1)

**Table S3b.** Magnesiowüstite maximum and minimum velocity magnitudes and directions, and corresponding percent anisotropy